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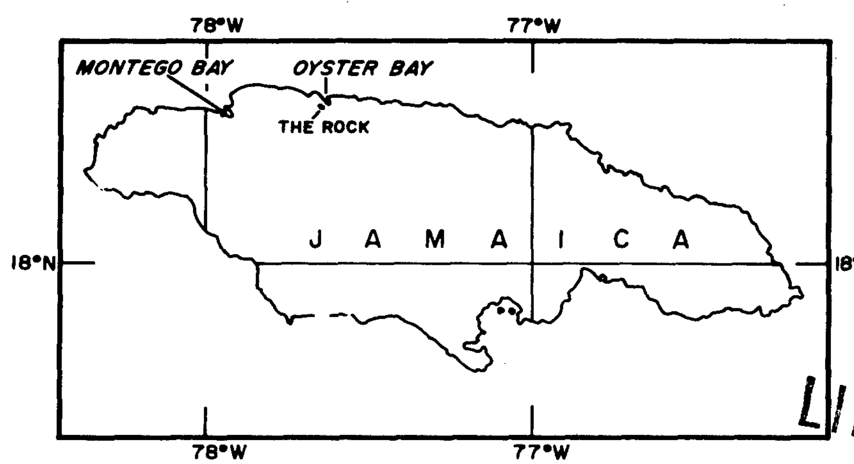
IR NO. 68-116

INFORMAL REPORT

OCEANOGRAPHIC CRUISE SUMMARY MARINE BIOFOULING STUDIES IN MONTEGO AND OYSTER BAYS, JAMAICA JANUARY 1967 TO JANUARY 1968



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NAVAL OCEANOGRAPHIC OFFICE
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INFORMAL REPORT

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ERRATA SHEET FOR IR NO. 68-116

Page 5 - Footnote 1 should read "one specimen on one unknown panel"

Page 9, Figure 4 - Weight in grams should read 0.50, 1.0, 1.50, and 2.0

Page 16 and Page 18 - Figure 6 caption goes with Figure 7 and vice versa

ABSTRACT

The U.S. Naval Oceanographic Office conducted biofouling studies in Montego Bay and Oyster Bay, Jamaica, from January 1967 to January 1968. The study was in cooperation with the McCullum-Pratt Institute of Johns Hopkins University with funds provided by the Office of Naval Research and the Atomic Energy Commission.

A total of 46 fouling panels was recovered from the two bays. The two sites showed a wide diversity in fouling organisms and in the quantity of biomass as follows:

(1) In Montego Bay, the fouling community was composed almost entirely of algae and a few soft bodied organisms. The biomass remained relatively small.

(2) In Oyster Bay, the growth of hard bodied foulers was rapid, and populations were dense. The biomass rapidly accumulated to a substantial quantity.

A theory is introduced that in certain habitats the seasonal rains may trigger reproduction and settlement in the barnacle, frequently the chief member of the fouling community.

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This report has been reviewed and is approved for release as an UNCLASSIFIED Informal Report.

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CONTENTS

FIGURES

TABLES

I. PREVIOUS KNOWLEDGE OF THE REGION

Few biofouling data have been collected in the waters off Jamaica. Goodbody (1961) of the University of the West Indies exposed fouling panels near Kingston, Jamaica, between October 1958 and September 1959 to collect data on tunicates. The panels were exposed near the surface in shallow water. In a series of 2-month exposures, he found that panels invariably developed a growth of hard foulers dominated by barnacles, tunicates, serpulid worms, lamellibranchs, and broyozoans. At one location, panels were submerged for a period of 26 months. Here, the dominant organisms were chiefly soft foulers, including several species of sponges and sea anemones with an associated fauna of crustaceans, polychaetes, and molluscs.

McElroy, et al. (1967) indicated from phosphate and iron analyses that Oyster Bay, Jamaica, is high in organic nutrients. The high nutrient content may be attributed to the dense stands of mangrove which border Oyster Bay and to the fresh water from the Martha Brae River.

II. OBJECTIVES

The McCullum-Pratt Institute of Johns Hopkins University and the U.S. Naval Oceanographic Office (NAVOCEANO) have been conducting cooperative studies on bioluminescence and biofouling in the waters off Jamaica. In 1965, the McCullum-Pratt Institute began a study of the possible causes of high primary productivity in certain bays of Jamaica. The study included a biological, chemical, and physical survey of Oyster Bay to determine the factors responsible for the bay's known high productivity.

Two areas were selected for the study: Montego Bay, an exposed bay of relatively low productivity, and Oyster Bay, a sheltered bay of relatively high productivity. The objective of the biofouling study was to show, primarily, that accumulated biomass might be a good indicator of productivity. Additional data were to be obtained on marine borer activity.

The Office of Naval Research and the Atomic Energy Commission provided funds for the biofouling study. NAVOCEANO furnished fouling panels, panel racks, and supplementary equipment for the study and analyzed the panels.

III. NARRATIVE OF OPERATIONS

Biofouling studies (Operation Number 927017) were conducted in Montego Bay and Oyster Bay, Jamaica, from January 1967 to January 1968 (Figs. 1 and 2).

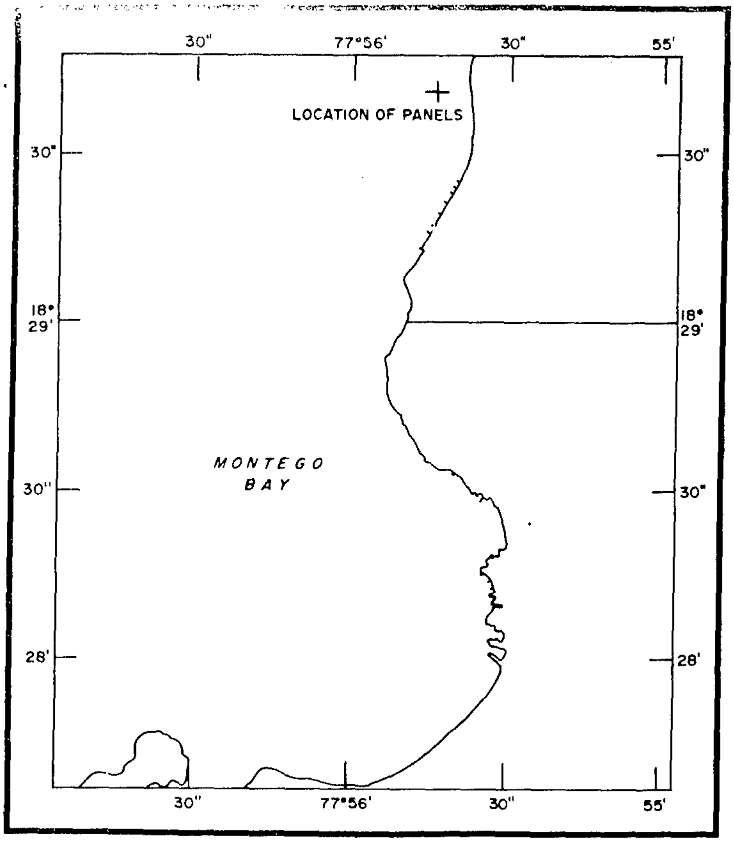

Figure 1. Location of Panels - Montego Bay

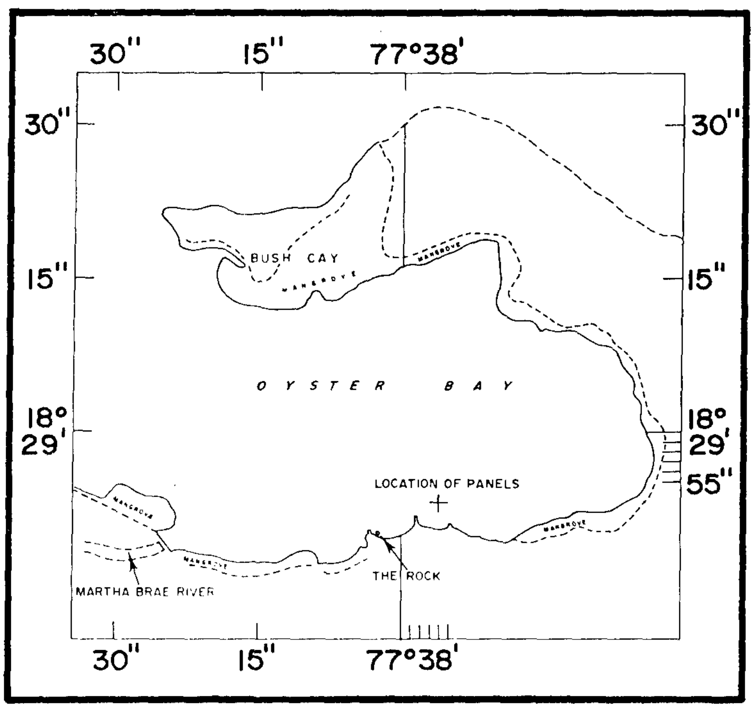

Figure 2. Location of Panels - Oyster Bay

The coordinates for the test sites were as follows:

Montego Bay:	18°29'40"N	77°55'44"W
Oyster Bay:	18°28'53"N	77°37'56"W

Test panels in Montego Bay were placed on a fine coral-sand bottom about 200 yards offshore at the end of the East-West runway at the international airport.

Test panels in Oyster Bay were attached to a bottom rack about 225 yards off "the rock", a local landmark on the south shore of the bay.

Panels were submerged and recovered monthly during the study period. At the time of recovery of the panels, surface and panel depth temperature and salinity measurements were obtained. A total of 46 panels was recovered from the two sites.

IV. METHODS OF COLLECTION AND ANALYSIS

Biofouling organisms were collected on non-toxic test panels. Each panel provided two 6- x 12-inch substrate surfaces. One surface consisted of a 1/4-inch thick asbestos sheet for collecting foulers, and the other surface consisted of a 3/4-inch thick white pine board for collecting marine borers. The panels were attached vertically to racks and exposed near bottom in water depths of 30 feet at Montego Bay and 6 feet at Oyster Bay. The racks for holding the panels were constructed of 2-inch diameter steel pipe, and they supported the panels about 2 feet above the bottom.

Before submerging a rack at each study site, 12 panels, one for each month, were attached to the rack to determine the cumulative biota in monthly increments for an entire year. At the end of the first month, divers retrieved one panel, replacing it with a new panel. At the end of the second and subsequent months, divers retrieved two panels and replaced one. One of the retrieved panels was from the original 12, and the other was the panel placed on the rack the previous month. Thus, starting with a 1-month coating of attached organisms, the series of panels showed the monthly and the accumulated biota in monthly increments for an entire year.

At each panel recovery, divers also took surface and panel depth temperature measurements and a surface and panel depth water sample for salinity analysis.

After the panels were retrieved, they were soaked in 95 percent ethyl alcohol for 48 hours and then were shipped to NAVOCEANO. At NAVOCEANO, the panels were analyzed by identifying the various organisms, determining their population density and size, and estimating the degree of wood damage by borers. Growth rates were determined by

measuring the maximum length of basal diameter of various indicator organisms attached to the cumulative panels. All fouling material then was scraped from the asbestos panels for dry weight determinations. The scraped biomass was placed in an oven, dried at 100°C, and weighed. To assure that all the moisture was removed from the biomass, the drying procedure was repeated until the dry weight was constant. The results of the above analysis, along with panel depth temperature and salinity data, were recorded on data summary sheets.

The biomass weights for Oyster Bay are only approximate. An error in weight was introduced by the loss of a certain amount of the biomass in removing the panels. Most of this loose material was retained but was mixed with additional material loosened from the wood surface in packing and shipping, further compounding the error. To date, the weights of biomass on the wood blocks have been disregarded.

V. DISPOSITION OF DATA

All data are retained on file at NAVOCEANO. A reference collection of specimens and the dried biomass scrapings and data summary sheets are filed under Operation Number 927017 (Montego Bay and Oyster Bay, Jamaica).

VI. PRELIMINARY ANALYSIS - FOULING ORGANISMS

A. Montego Bay.

The outstanding characteristic of the fouling biomass at Montego Bay was the relatively heavy growth of soft foulers, chiefly red algae, and the absence of hard foulers, particularly barnacles. In this respect, fouling at Montego Bay was in contrast to the fouling at Oyster Bay where hard foulers dominated. The presence of red algae in abundance appeared to exclude barnacles and vice versa. The monthly and cumulative fouling organisms are presented in Tables I and II, respectively, and the weights of biomass on the monthly and cumulative panels are tabulated in Tables III and IV, respectively. Figure 3 shows a graph of the wet weight of the fouling biomass on the monthly and cumulative panels, and Figure 4 shows graphs of the wet and dry weights of fouling biomass on the monthly panels.

1. The Monthly Panels. A typical summer monthly panel showed a complete thin coating of diatoms. At least four species of algae attached on the monthly panels as compared with more than 12 species on the cumulative panels. *Polysiphonia* sp. was present on the August to December panels and covered 30 percent of a panel surface during November but only a trace during the other months.

The alga *Champia parvula* did not appear until early August although a prevalent alga as shown by the cumulative panels. This form reached a maximum length of 5.5cm on the final panel from December 1967 to January 1968. *Ectocarpus* sp. and an unidentified species of Corallinacae also were present on some of the monthly panels.

Table 1. Monthly Fouling - Montego Bay

Panel Number	336			348			345			350			351		
Submergence Date	Jan 17			Feb 7			Mar 8			Apr 14			May 12		
Removal Date	Feb 7			Mar 8			Apr 14			May 12			Jun 6		
Days Submerged	21			29			37			28			25		
Fouling Organisms	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%
ALGAE Diatomaceae											T 1mm	100		T 1mm	100
Chlorophyceae *Polysiphonia* sp.															
Rhodophyceae *Champia parvula*															
Phaeophyceae *Ectocarpus* sp.								max L 25mm	15		L 5-10mm	5		L 10mm	5
Corallinaceae Unidentified sp.															
PROTOZOA Foraminifera *Quinqueloculina*										150	D 0.1mm	Tr			
COELENTERATA Hydrozoa Unidentified sp.	1	L 50mm	1						Tr						
ANNELIDA Polychaeta Sedentaria *Hydroides norvegica*										1	L 5mm				
Unidentified spp.															
Errantia										12	L 1-3.5mm	Tr*			
ARTHROPODA Crustacea Copepoda *Metis* sp.										25	L 1.5mm				
Tanaidacea *Tanais cavolinii*[1]															
Leptochelura savignii										1	L 5mm	Tr			
Amphipoda *Tropichelura insulae*										1	L 0.5mm		1		Tr
Gammaridea unidentified sp.															
Decapoda *Mithrax cinctimanus*															
MOLLUSCA Gastropoda Vermitidae *Dendropoma corrodens*															
Lamellibranchia unidentified sp.										1	L 1mm				
BRYOZOA Ectoprocta *Thalamoporella falcifera*	150	max D 45mm	10							12 col	av ? 1.5mm		15	max 1.0cm²	1
Bugula neritina										1 col	? 5mm				
Unidentified Eggs															
PROTOCHORDATA Tunicata											L 2-3mm				
Boring Organisms ARTHROPODA Crustacea Isopoda *Limnoria* sp.	8			5									2		

Panel Number	352			353			354			355			356			357			358		
Submergence Date	Jun 6			Jul 5			Aug 5			Sep 5			Oct 6			Nov 6			Dec 5		
Removal Date	Jul 5			Aug 5			Sep 5			Oct 6			Nov 6			Dec 5			Jan 8		
Days Submerged	29			31			31			31			31			29			34		
Fouling Organisms	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%
ALGAE Diatomaceae		T 1mm	100		T 1mm	90								T 1mm	100						
Chlorophyceae *Polysiphonia* sp.								L 7-8mm	Tr		L 6-7mm	Tr		L 15mm	** Tr	sparse	max 6-7mm	30			Tr
Rhodophyceae *Champia parvula*							1		1		L 4mm	Tr		max L 30mm	** 2	2 6	max L 15mm max L 50mm	1 *	5	max L 55mm	2
Phaeophyceae *Ectocarpus* sp.			2	sparse	L 9-10mm	90															
Corallinaceae Unidentified sp.				10 patches	D 10mm	4.5				5	D 3mm	Tr				6	max D 5mm	Tr	Tr	D 1-3mm	Tr
PROTOZOA Foraminifera *Quinqueloculina*			Tr				12	D 0.1mm	Tr												
COELENTERATA Hydrozoa Unidentified sp.																					
ANNELIDA Polychaeta Sedentaria *Hydroides norvegica*							2	L 5mm	Tr												
Unidentified spp.																					
Errantia										1	L 2.5mm	Tr	1-2	L 7.5mm	Tr				8	max D 0.5mm	Tr
ARTHROPODA Crustacea Copepoda *Metis* sp.							6		Tr				4		Tr						
Tanaidacea *Tanais cavolinii*[1]																					
Leptochelura savignii	6	L 5mm	Tr				1	L 5mm	Tr												
Amphipoda *Tropichelura insulae*	1																				
Gammaridea unidentified sp.																					
Decapoda *Mithrax cinctimanus*	1		Tr				1	L 1mm	Tr												
MOLLUSCA Gastropoda Vermitidae *Dendropoma corrodens*							4	D 1mm	Tr				1		Tr	1	D 0.8mm	Tr	1	D 0.5mm	Tr
Lamellibranchia unidentified sp.																					
BRYOZOA Ectoprocta *Thalamoporella falcifera*																					
Bugula neritina																					
Unidentified Eggs																					
PROTOCHORDATA Tunicata												Tr									
Boring Organisms ARTHROPODA Crustacea Isopoda *Limnoria* sp.	6-10			12			17		Tr	6-10		Tr									

1 One unknown specimen on one unknown panel
* Wood Panel
** Occurred on both wood and asbestos panel

L= length D= diameter Tr= trace
T= thickness W= width

Table II. Cumulative Fouling – Montego Bay

Panel Number	336			337			338			339			340			341			342			343			344			345			346			333		
Submergence Date	Jan 17			Jan 17			Jan 17			Jan 17			Jan 17			Jan 17			Jan 17			Jan 17			Jan 17			Jan 17			Jan 17			Mar 8		
Removal Date	Feb 7			Mar 8			Apr 14			May 12			Jun 6			Jul 5			Aug 5			Sep 5			Oct 6			Dec 5			Jan 8			Jan 8		
Days Submerged	21			50			87			115			139			159			200			231			262			322			356			306		
Fouling Organisms	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%
ALGAE Diatomacea														T 1mm	100					T 1mm	90		T 1mm	80		T 5mm	90								T 1mm	70
Chlorophyceae Dasycladus vermicularis																2	6mm	Tr															Tr			
Polysiphonia sp.				7		Tr					L 5-15mm	55				num	T 1-3mm	85	num	3-4mm	70	num		90	num	L 5-7mm	80				num	L 0.5mm	20			
Acetabularia sp.																															1	D 7mm	Tr			
Corallinaceae Unidentified sp.									Tr							num	D 2-8mm				Tr		W 25mm	8	6	1cm²	2		patches 1cm²	Tr	num	D 6mm	13			
Phaeophyceae Herposiphonia sp.																															few		Tr			
Dictyota sp.				7	max L 20mm	2						Tr							num	4-5mm	1															
Pocockiella sp.							15	28cm²	8							1	D 5mm	Tr	7	max 40-50mm	5	5	W 10mm	1	25	D 12-15mm		6	max area 1cm²	2						
Padina sp.				8	D 6-12mm	Tr							4	D 6-7mm	3	1	4mm	Tr					W 25mm	Tr												
Ectocarpus sp.														L 10-15mm	50																					
Rhodophyceae Champia parvula							many	max 40-50mm	33							num	max D 15mm	Tr	10	L 15mm	2	num	max 20mm	6	num	L 35mm	25	num	max L 100mm	25	35	max D 140mm	15	sparse	max L 20mm	30
Microcoleus lyngbya																						num		Tr												
Champia salicornoides																1		Tr																1	L 7.5mm	Tr
PROTOZOA Foraminifera Quinqueloculina																num		Tr	num			num	max D 0.2-0.5mm	Tr	num		Tr	few		Tr						
PORIFERA Haliclona sp.										1	max L 25mm W 5mm	Tr							1	5mm	Tr															
Unidentified sp.										1	H 2mm	Tr																								
COELENTERATA Hydrozoa Alcyonaria sp.										1	D 20-25mm	2																								
Unidentified sp.	1	L 50mm																																		
Anthozoa Unidentified sp.														H 7mm	Tr																					
ANNELIDA Polychaeta Sedentaria Hydroides norvegica				1	L 7.5mm	Tr				3	L 8mm	Tr							50	L 5-6mm D 0.8mm	2	80	L 12mm	Tr	num	D 0.12mm	Tr	2	L 12mm		10		Tr			
Crythroe companulata										1		Tr																								
Unidentified sp.				1	D 1.5mm	Tr	8-10		Tr										1	20mm tube	Tr	3	L 4mm		few	8-25mm	Tr				1	D 1mm	Tr			
Errantia Unidentified sp.									Tr	4	L 5mm	Tr	1	L 10-12mm		few	5-7mm	Tr	few	10mm	Tr													3		Tr
Sipunculoidea																						1	L 15mm	Tr												
ARTHROPODA Crustacea Cirripedia (larvae) Balanus sp.																																		3		Tr
Copepoda Metis sp.										1		Tr							few		Tr	est 100	L 2mm	Tr	few		Tr							few		Tr
Tanaidacea Leptochelia savignyi																few		Tr	few		Tr							few		Tr						
Amphipoda Tropichelura insulae																			few	L 5mm	Tr	1	L 6mm	Tr				1 or 2	L 3mm	Tr	few	L 4mm	Tr			
Gammaridea Unidentified sp																									few		Tr									
Decapoda Stenopus hispidus																															1	L 20mm	Tr			
MOLLUSCA Gastropoda Vermetidae Dendropoma corrodens							6	D 2mm	Tr	1		Tr				1		Tr				1	D 7mm	Tr	6	max D 8mm	Tr									
BRYOZOA Ectoprocta Thalamoporella falcifera	150	max D 45mm	10							50	max D 12.5mm	18	31	L 25mm max D 4mm	Tr																					
Stylopoma spongites															Tr						Tr															
PROTOCHORDATA Tunicata Botryllus sp.												1																								
*Boring Organisms																																				
ARTHROPODA Crustacea Isopoda Limnoria tripunctata	8			6			num			75-80			num					100	num						num		100	num		100	num		100	9		
MOLLUSCA Teredo sp.							num									2			num			num			18	D 8mm Burrows		num		100	num		100			

* Wood Panel

Table III. Weights of Fouling Biomass on Monthly Panels - Montego Bay

Panel Number	Wet Weight (grams)	Dry Weight (grams)	Days of Exposure	Period of Submergence	Panel $T^{o}C$	Depth S^{o}/oo
336	Lost		21	Jan. 17 Feb. 7	26.90 26.76	37.80 35.80
348	No Measurable Fouling		29	Feb. 7 Mar. 8	26.98	36.98
349	No Measurable Fouling		37	Mar. 8 Apr. 14	26.23	35.78
350	No Measurable Fouling		28	Apr. 14 May 12	27.98	36.02
351	No Measurable Fouling		25	May 12 June 6	27.98	36.18
352	0.35	0.35	29	Jun. 6 July 5	28.78	36.21
353	0.61	0.50	31	July 5 Aug. 5	-	-
354	0.35	0.25	31	Aug. 5 Sep. 5	-	-
355	0.50	0.30	31	Sep. 5 Oct. 6	29.30	35.60
356	1.70	0.55	31	Oct. 6 Nov. 6	28.62	35.78
357	0.81	0.35	29	Nov. 6 Dec. 5	27.96	35.73
358	1.30	0.92	34	Dec. 5 Jan. 8-68	27.32	35.75

Table IV. Weights of Fouling Biomass on Cumulative Panels - Montego Bay

Panel Number	Wet Weight (grams)	Dry Weight (grams)	Days of Exposure	Period of Submergence	Panel Depth T°C	S°/oo
336	Lost		21	Jan. 17 Feb. 7	26.90 26.76	37.80 35.80
337	Lost		50	Jan. 17 Mar. 8	26.98	36.98
338	20.80	5.83	87	Jan. 17 Apr. 14	26.23	35.78
339	6.14	Lost	115	Jan. 17 May 12	27.98	36.02
340	Lost		139	Jan. 17 June 6	27.98	36.18
341	7.38	2.02	169	Jan. 17 July 5	28.78	36.21
342	8.25	2.35	200	Jan. 17 Aug. 5	-	-
343	11.50	2.80	231	Jan. 17 Sep. 5	-	-
344	6.95	2.57	262	Jan. 17 Oct. 6	-	-
345	13.90	3.45	322	Jan. 17 Dec. 5	27.96	35.73
346	18.70	4.75	356	Jan. 17-67 Jan. 8-68	27.32	35.75
347	Lost during storm of 26 February and replaced with Panel 333.					
333	3.20	0.57	306	Mar. 8 Jan. 8-68	26.98 27.32	36.98 35.75

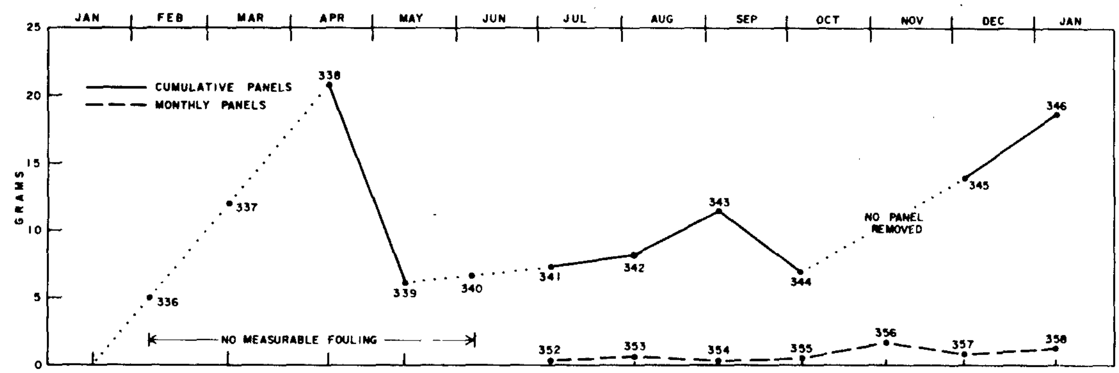

Figure 3. Wet Weight of Fouling Biomass on Monthly and Cumulative Panels - Montego Bay

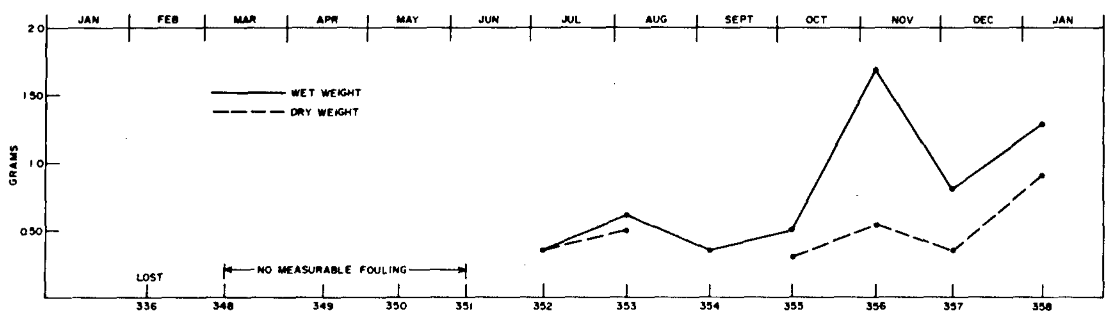

Figure 4. Dry and Wet Weight of Fouling Biomass on Monthly Panels - Montego Bay

Foraminifera were scarce on the monthly panels, and their settlement was limited to summer months. An unidentified species of Hydrozoa appeared in trace amounts on two panels.

Hydroides norvegica was the only calcareous tube worm and appeared on only two panels. Free-living polychaetes were present but also in trace amounts.

Motile crustaceans in association with algae were scarce on monthly panels. A few scarlet copepods (*Metis* sp.) and tanaids occurred on four panels. The absence of barnacles has been noted above. The amphipod *Tropichelura insulae*, which lives in the burrows of the gribble (*Limnoria* sp.), was present in small numbers on early summer panels. A spider crab (*Mithrax cinctimanus*) was collected on one panel. At least one species of coiled molluscs (Vermetidae) attached in trace amounts. The sole lamellibranch was a small specimen on the April to May panel. Bryozoa presented practically no fouling problem on these panels and did not occur after June except for a trace on the September panel.

2. The Cumulative Panels. The chief component of the heavy algal growth on the cumulative panels was the red alga *Champia parvula*. No algal settlement appeared the first month. Settlement and growth of three species, *Polysiphonia* sp., *Dictyota* sp., and *Padina* sp., began between February and March. Between 8 March and 14 April, *Pocockiella variegata* and *Champia parvula* attached, and the algae measured 5.0cm. By 12 May, an open mat of *Polysiphonia* sp. covered 95 percent of the surface with a maximum thickness of 15mm.

The April panel showed a heavy growth of *Champia parvula* well underway. This panel was 33 percent covered by an open mat to a maximum thickness of 5.0cm. However, cumulative panels retrieved during summer showed considerably smaller amounts of this alga, perhaps due to grazing by fishes. Growth continued with renewed vigor after the August maximum water temperatures were passed, and a length of 14.0cm was reached by January 1968. Among the several additional species attached and growing on the September through December panels, *Ectocarpus* sp. appeared as the dominant fouler. Panels submerged from May to October were 50 to 100 percent covered with a film of diatoms.

Calcareous algae (Corallinaceae) of undetermined species appeared as a trace by 14 April but did not grow vigorously until June-July. Growth continued through January with a thin 1- to 2-mm coating that covered 15 percent of the panel.

Errant polychaete worms became increasingly numerous as the algal mat increased in density and variety. Tubeworms showed preference for barnacle beds and consequently were scarce on all cumulative panels.

Barnacles, aside from a few cypris larvae, avoided settling on the Montego Bay panels. As the algal mat thickened in late summer

and autumn, the small copepod *Metis* sp. increased although it was never numerous.

The tanaid crustacean *Leptochelura savignyi* was occasional after mid-June. On a panel removed on 8 January 1968, a feeder shrimp (*Stenopus hispudus*) was collected. The specimen showed an unusual green coloration instead of the normal white.

The only mollusc found on the cumulative panels was the coiled mollusc (Vermetidae). Only one species was positively identified: *Dendropoma corrodens*.

Bryozoa was a minor part of the fouling complex and was represented by only two species, *Stylopoma spongites* and *Thalamoporella falcifera*. These species covered 10 to 50 percent of each of the panels removed between February and May. *Stylopoma* sp. occurred in trace amounts on two panels. Hydroid fouling was minimal.

B. Oyster Bay.

The monthly and cumulative fouling organisms are presented in Tables V and VI, respectively, and the weights of biomass on the monthly and cumulative panels are tabulated in Tables VII and VIII, respectively. Figure 5 shows a graph of the wet weight of fouling biomass on the monthly and cumulative panels, and Figure 6 shows graphs of the wet and dry weights of fouling biomass on the monthly panels.

1. *The Monthly Panels*. Algal fouling was practically nonexistent on any of the 1-month exposure panels. Fouling by sponges was negligible, but the August panel was 40 percent covered with a 1-mm thickness of an encrusting sponge.

Traces of hydroid settlement occurred in May and on the September, October, and December panels.

A specimen of the calcareous tube worm *Hydroides norvegica* occurred on the May panel. A cluster of about 10 small individuals of this species, or a similar form, occurred as a trace on the December panel.

One species of *Marphysa* sp. in July was the only errant polychaete collected on these panels.

Barnacle (*Balanus* sp.) settlement occurred in every month and was heaviest in April and May (2,375 per panel). A second period of heavy barnacle settlement existed in October and early November, but a rapid decline followed in December and January. A close correlation existed between the onset of the rains and the season of reproduction and settlement of *Balanus eburneus* (Fig. 7). The period of maximum reproduction appeared to follow slightly the period of maximum rainfall in both the spring and fall settlement periods. The physiological background of this feature of the barnacle life cycle is not yet

Table V. Monthly Fouling - Oyster Bay

Panel Number	307			319			320			321			322		
Submergence Date	Jan 5			Feb 6			Mar 7			Apr 11			May 12		
Removal Date	Feb 6			Mar 7			Apr 11			May 12			Jun 6		
Days Submerged	29			35			35			31			25		
Fouling Organisms	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%
PORIFERA Unidentified sp.															
COELENTERATA *Campanularia* sp.													few		Tr
ANNELIDA Polychaeta Sedentaria *Hydroides norvegica*													1	L 20mm	Tr
Unidentified sp.						Tr									
Errantia *Marphysa* sp.															
ARTHROPODA Crustacea Cirripedia *Balanus eburneus*	1575	max L 12.5mm W 11mm H 10mm	57	800	max L 12mm W 10mm av H [illegible]	80	1500	max L 12mm W 11mm H 4mm	98	[illegible]	max L 13mm W 11mm H 10mm	98	2375	max L 12mm W 10mm H 9mm	98
Copepoda *Metis*	few														
BRYOZOA Ectoprocta *Bugula neritina*	3	max L 30mm W 60mm	5	125	H 25mm	60	12	H 10mm max W 20mm	Tr	6	L 10mm Area 1cm^2	1			
Crassimarginatella tuberosa															
PROTOCHORDATA Tunicata *Botryllus* sp.															

Panel Number	323			324			325			326			327			328			329		
Submergence Date	Jun 6			Jul 6			Aug 5			Sep 7			Oct 13			Nov 8			Dec 10		
Removal Date	Jul 6			Aug 5			Sep 7			Oct 13			Nov 8			Dec 10			Jan 9		
Days Submerged	30			30			33			36			26			32			30		
Fouling Organisms	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%
PORIFERA Unidentified sp.							1 sheet	T 1mm	40			50			70						
COELENTERATA *Campanularia* sp.										1	L 50-70mm	1	1	L 40mm	Tr						Tr
ANNELIDA Polychaeta Sedentaria *Hydroides norvegica*																					
Unidentified sp.																			10		Tr
Errantia *Marphysa* sp.				4		Tr															
ARTHROPODA Crustacea Cirripedia *Balanus eburneus*	[illegible]	av L 8mm H 4mm	96	775	max L 14mm H 11mm	57	1150	max L 12mm H 6mm	95	1100	max L 16mm H 5mm	100	[illegible]	max L 12mm H 5mm	100	2000	max L 10-20mm H 6mm	100	200	max L 10mm H 5mm	50
Copepoda *Metis*																					
BRYOZOA Ectoprocta *Bugula neritina*	16	max L 24mm W 10mm	5	76	H 30-60mm W 80mm	40	80	max L 45mm H 45mm	30	2	L 20mm	2	1	15mm	Tr	1	max H 10mm	Tr	num	max H 30mm	75
Crassimarginatella tuberosa				6	Area 6.45cm^2	Tr				1	6cm^2	Tr				1	1cm^2	Tr	4	5cm^2	Tr
PROTOCHORDATA Tunicata *Botryllus* sp.								Zoids 1mm	40												

Table VI. Cumulative Fouling - Oyster Bay

Panel Number	307			306			309			310			311			312			313			314			315			316			317			318		
Submergence Date	Jan 5			Jan 5			Jan 5			Jan 5			Jan 5			Jan 5			Jan 5			Jan 5			Jan 5			Jan 5			Jan 5			Jan 5		
Removal Date	Feb 6			Mar 7			Apr 11			May 12			Jun 6			Jul 6			Aug 5			Sep 7			Oct 13			Nov 8			Dec 10			Jan 5		
Days Submerged	32			61			96			127			152			182			212			245			281			307			339			365		
Fouling Organisms	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%	No	Size	%
COELENTERATA *Lafoea* sp.										6	100 mm	5				few		Tr							7	L 40mm	1				num	L 50mm	25	num	max L 50mm	15
Campanularia sp.				10	av L 20-40mm	5						5				few	L 10-15mm	Tr	7	L 120mm	5	num		65												
ANNELIDA Polychaeta Sedentaria *Branchioma nigromaculatus*										num	L 20-40mm	3				few	L 80-100mm	Tr				num	max L 50mm	Tr												
Eupomatus santiaecrucis																			3	L 20mm	Tr															
Polydora sp.										num		3																								
Errantia *Marphysa* sp.																2	80-100mm	Tr																		
Unidentified sp.				1		Tr																														
ARTHROPODA Crustacea Cirripedia *Balanus eburneus*	1575	max L 12.5 mm W 11mm H 10mm	97	2000	max L 12mm W 6mm H 18.5mm	100	1400	max L 21mm H 31mm	100	400	max L 21mm W 20mm H 25mm	100	750	max L 23mm W 15mm P 23mm	100	800	max L 22mm	75	900	max H 24mm D 18mm	100	1000	max L 27mm P 27mm	100	1500	max W 15mm H 30mm	100	1800	max W 10mm H 22mm	100	3000	max W 23mm H 25mm	100	2000	max W 21mm H 30mm	100
Copepoda *Ketis* sp.	few																																			
Decapoda *Hexapanopeus carricaeus*													2	J 6mm	Tr	6	J 6mm	Tr	?	W 8mm	Tr	5	W 6-8mm	65												
Alpheus viridari																1	L 20mm																	2	D 6-8mm	Tr
																																		1	D 6-8mm	
MOLLUSCA Lamellibranchia *Mytilopsis sallei*				1	L 6mm	Tr																														
Isognomon radiata																			2	18-35mm	3	1		Tr	3	L 20-20mm	Tr									
Branchchidontes exustus																			1	15mm	Tr															
BRYOZOA Ectoprocta *Bugula neritina*	3	max L 30mm W 60mm	5	10	10cm²	5	2	max L 60mm	2	7	max L 100mm	Tr	few		Tr				4	L 30mm	3				1	L 20mm	Tr	1	L 15mm	Tr	1	L 15mm	Tr		L 25-30mm	20
Crassimarginatella tuberosa			50				1		2																	2 cm²	Tr	1	1cm²	Tr		5cm²	2	1	1cm²	4
PROTOCHORDATA Tunicata *Botryllus* sp.							2	45cm²	10								T 2mm	75		L 115mm	15			40										1	7.5 x 10.2 cm	12

Table VII. Weights of Fouling Biomass on Monthly Panels - Oyster Bay

Panel Number	Wet Weight (grams)	Dry Weight (grams)	Days of Exposure	Period of Submergence	Panel Depth T^oC	S^o/oo
307	232.60	198.70	32	Jan. 5 Feb. 6	26.90 28.60	32.00 35.25
319	64.60	40.90	29	Feb. 6 Mar. 7	29.20	34.50
320	265.99	206.60	35	Mar. 7 Apr. 11	29.32	34.94
321	201.60	180.60	31	Apr. 11 May 12	29.62	35.51
322	211.20	163.90	25	May 12 June 6	29.34	35.12
323	183.30	121.10	30	June 6 July 6	30.40	34.61
324	232.00	104.90	30	July 6 Aug. 5	31.38	34.71
325	254.10	166.00	33	Aug. 5 Sep. 7	31.20	34.88
326	322.60	249.40	36	Sep. 7 Oct. 13	29.62	33.64
327	165.50	121.30	26	Oct. 13 Nov. 8	29.53	34.42
328	243.50	214.50	32	Nov. 8 Dec. 10	28.43	34.64
329	22.70	18.20	30	Dec. 10 Jan. 9	27.41	33.34

Table VIII. Weights of Fouling Biomass on Cumulative Panels - Oyster Bay

Panel Number	Wet Weight (grams)	Dry Weight (grams)	Days of Exposure	Period of Submergence	Panel T°C	Depth S°/oo
307	232.60	198.7	32	Jan. 5 Feb. 6	26.90 28.60	32.00 35.25
308	532.20	401.80	61	Jan. 5 Mar. 7	29.20	34.50
309	501.60	428.10	96	Jan. 5 Apr. 11	29.32	34.94
310	494.50	478.10?	127	Jan. 5 May 12	29.62	35.51
311	930.40	653.80	152	Jan. 5 June 6	29.34	35.12
312	1,471.30	933.50	182	Jan. 5 July 6	30.42	34.61
313	1,514.40	1,203.80	212	Jan. 5 Aug. 5	31.38	34.71
314	1,278.30	911.10	245	Jan. 5 Sep. 7	31.20	34.88
315	872.80	696.20	281	Jan. 5 Oct. 13	29.62	33.64
316	850.20	685.70	307	Jan. 5 Nov. 8	29.53	34.42
317	805.20	651.20	339	Jan. 5 Dec. 10	28.43	34.64
318	564.30	426.30	369	Jan. 5-67 Jan. 9-68	27.41	33.34

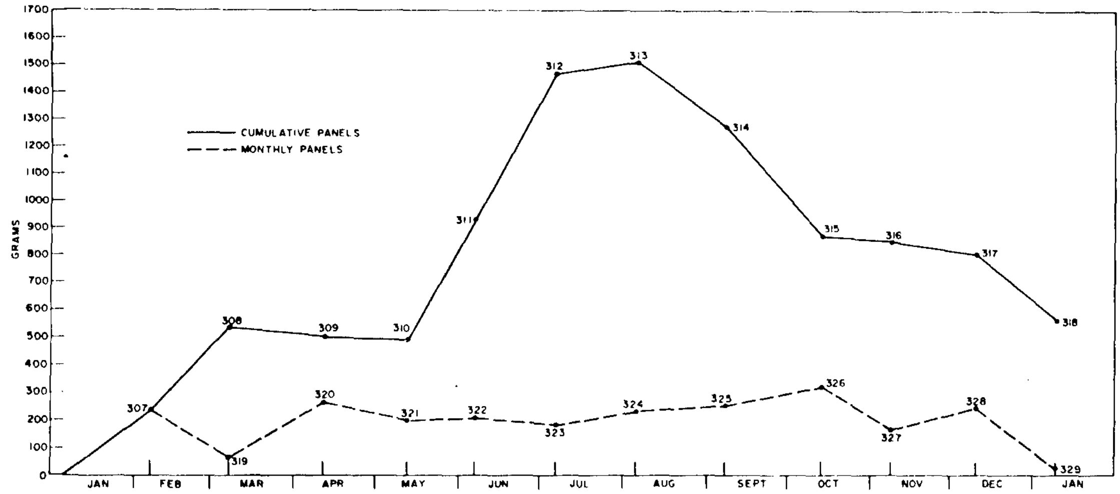

Figure 5. Wet Weight of Fouling Biomass on Monthly and Cumulative Panels - Oyster Bay

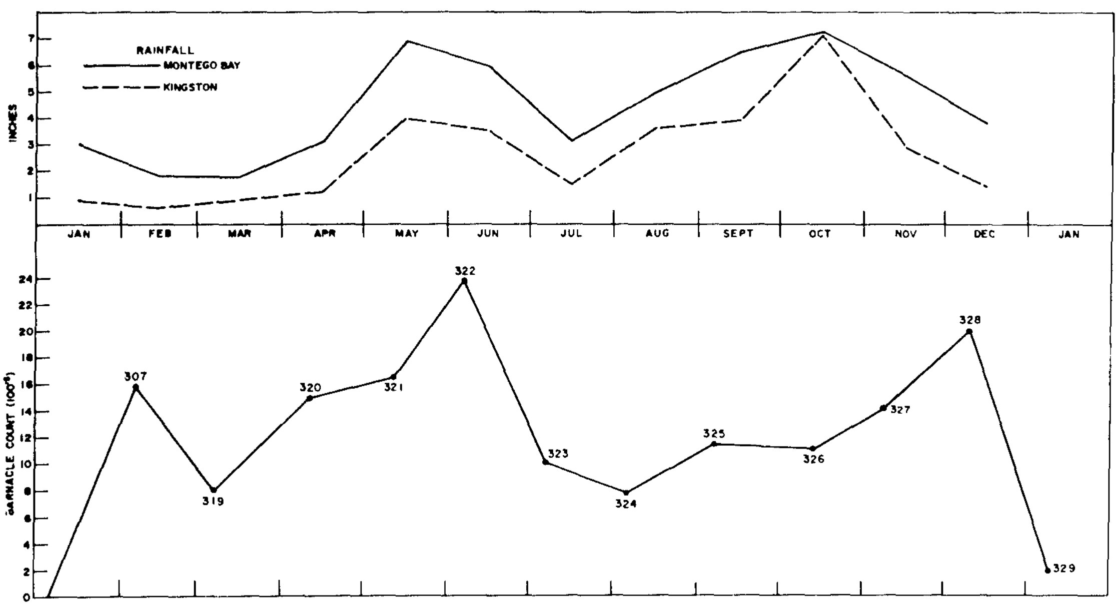

Figure 6. Dry and Wet Weight of Fouling Biomass on Monthly Panels - Oyster Bay

definitely known. The following are factors associated with the start of the rainy seasons which may influence barnacle settlement: 1) a change in nutrients from increased riverine influx, and 2) a decrease in percentage of sunlight that resulted from an increase in cloud cover.

The only significant Bryozoa fouling consisted of the erect, branching species, *Bugula neritina*. Settlement of this species was greatest in February when up to 125 organisms per panel attached and reached about 2.5cm in length. Growth appeared to be at a maximum in July when the largest specimens reached 4cm in length. *Crassimarginatella tuberosa* was the only other bryozoa appearing in abundance, and it never covered more than 2 percent of the asbestos panel.

The tunicate *Botryllus* sp. occurred on the August panel and covered 40 percent of the surface.

2. The Cumulative Panels. On all panels, algal fouling virtually was absent. A sponge appeared to be associated with a tunicate, and a membraneous growth was formed which covered about 5cm of the January through August panel.

Two genera of hydroids, *Lafoe* sp. and *Campanularia* sp., appeared on the panels. *Lafoe* sp. first appeared in April or May and exhibited its maximum length of 10cm during this time. *Campanularia* sp. first appeared in February and March and grew rapidly through August. *Campanularia* sp. was not found on panels retrieved after September, perhaps as a result of grazing by fishes. Maximum hydroid growth reached a length of 12cm in early August, and by early September, growth covered 65 percent of a panel.

Sizeable populations of tubeworms (Polychaeta) were established in the interstices of the barnacle colony which covered each panel. Worms of several species were present, including numerous free-living worms of which many occurred coiled under the thalli of the alga *Pocockiella* sp. Most of the tubeworms were between 8 and 10cm long with tubes of semiflexible chitinous material firmly anchored in and surrounded by barnacles. A few specimens of the polychaete *Hydroides norvegica* deposited a calcareous tube that was cemented tightly to the panel surface or to barnacles in trace amounts.

Barnacle growth (*Balanus eburneus*) was rapid with a maximum of about 3cm in 3 months. Barnacle coverage was practically 100 percent of all cumulative panel surfaces for all months except July (75 percent). The average thickness of the barnacle colony was about 2.5cm by July. A double layer of barnacles occurred in some cases as one grew on top of the other. Between mid May and early September, a few small crabs (*Hexapanopeus carribaeus*) were present in the barnacle colony. The snapping shrimp *Alpheus viridari* rarely occurred.

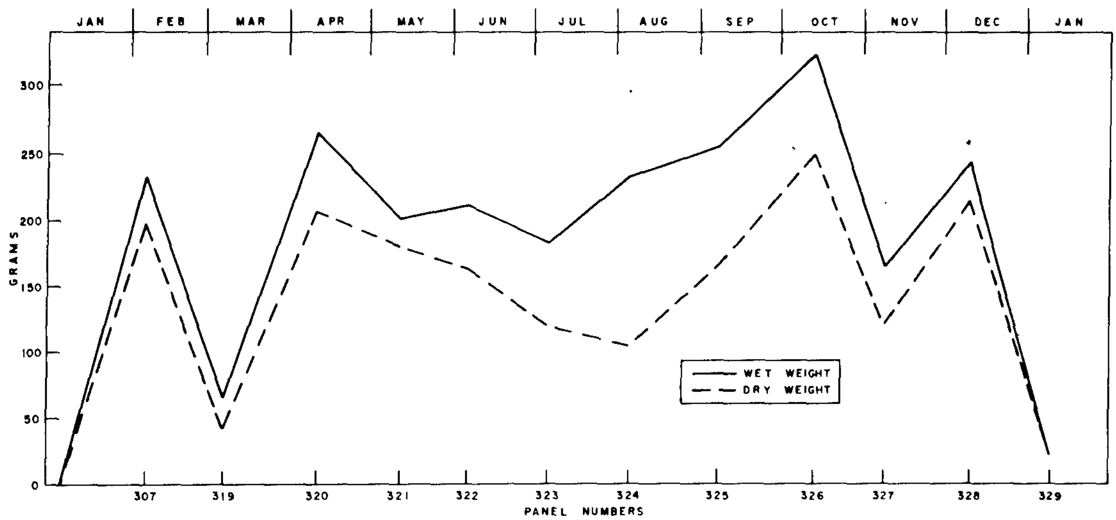

Figure 7. Comparison of Barnacle Larvae Settlement with Monthly Rainfall at Oyster Bay

Molluscan fouling was unimportant and was limited to three species, all of which were scarce. The flat tree oyster Isogomon radiata attained a length of 3.5cm and occurred in August, September, and October. One scorched mussel, Branchidontes exustus, occurred on the panel removed in August. A false mussel, Mytilopsis sallei, was on the March panel.

A light growth of Bugula neritina, the bulkiest of the local Bryozoa, was present throughout most of the year but was missing on the July and September panels. Maximum coverage of about 20 percent was reached in December. The encrusting bryozoan Crassimarginatella tuberosa covered up to 50 percent of the panel surface in the first month but later was crowded out by barnacle growth. Its colonies formed a sheet about 1- to 2-mm thick.

Tunicates were important foulers during July, August, and September and covered from 15 to 75 percent of the panel surface. Tunicates appeared in April, July, August, September, and January 1968.

VII. PRELIMINARY ANALYSIS - BORING ORGANISMS

A. Montego Bay.

Boring organisms, confined to Limnoria spp. and Teredo spp. in these waters, were numerous in all seasons in the low nutrient waters of Montego Bay. Teredo attack was not apparent on monthly panels.

During spring and summer months, Limnoria sp. inflicted light damage on panels exposed for 25 to 31 days. Between late September and January, panels exposed 29 to 34 days showed no borer damage by Limnoria sp.

Limnoria damage became extensive in 3 months' time at least during the period from January to March when up to 1/4 inch of the wood panel surface had been riddled. Damage became progressively more intensive and was severe after 6 months.

Teredo damage ranged from medium in 3 months (17 January to 14 April) to heavy by October on panels submerged in January.

B. Oyster Bay.

In the high nutrient waters of Oyster Bay, borers virtually were absent in all seasons.

VIII. SUMMARY

The Montego Bay and Oyster Bay panel sites showed a wide diversity in fouling organisms and in the quantity of biomass. In the exposed waters of Montego Bay, the fouling community was composed almost entirely of algae and a few soft bodied organisms. The biomass remained relatively small.

In the shallower, warmer waters of Oyster Bay, settlement and growth of hard foulers was rapid, and populations were dense. The biomass rapidly accumulated to a substantial quantity.

In Montego Bay, growth of benthic plant biomass accelerated in fall and winter which possibly is correlated with cooler water and better circulation from trade wind action. The growth of biomass was retarded in the summer months as water temperatures increased.

In Oyster Bay, animal biomass increased in weight for the first 6 months and decreased for the second 6 months. A positive correlation existed between the growth cycle and the monthly rainfall.

Boring organisms, *Limoria* spp. and *Teredo* spp., were numerous at all seasons in the low nutrient waters of Montego Bay. In the high nutrient waters of Oyster Bay, borers virtually were absent in all seasons.

IX. ADDITIONAL WORK NEEDED IN THE REGION

In most sectors of the oceans, the abundance, growth, and population densities of the components of the biofouling community follow a long term cycle, often with a phase of several years. More obvious in the temperate and subtropical biota zones is the seasonal or annual cycle. To obtain the best data on fouling, both the annual and the long term fouling cycles should be considered. For this reason, NAVOCEANO has customarily continued fouling study projects over a period of 3 to 5 years. A similar period of study at Montego and Oyster Bays is recommended, particularly because the regime of fouling cycles in the tropics is relatively unknown.

Useful supplemental data could be obtained by setting a third rack of panels in a sheltered position at a depth of 6 feet in Montego Bay which would be more nearly comparable with the data collected at Oyster Bay.

Hopefully, some method eventually will be found to increase productivity of less productive bays in Jamaica by increasing the protein deficiencies.

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XI. BIBLIOGRAPHY

Goodbody, I., 1961. Inhibition of the Development of a Marine Community. Nature, Vol. 190, pp. 282-283.

McElroy, W. D., Seliger, H. H., *et al*., 1967. Physical and Biological Oceanography of a Luminous Bay. Annual Progress Report: McCullum-Pratt Institute, The Johns Hopkins University. (UNPUBLISHED REPORT).

Taylor, W. Roland, Seliger, H. H., Fastie, W. G., and McElroy, W. D., 1966. Biological and Physical Observations on a Phosphorescent Bay in Falmouth Harbor, Jamaica. W. I. Journal of Marine Research. Vol. 24, No. 1, pp. 1-43.

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13. ABSTRACT

The U.S. Naval Oceanographic Office conducted biofouling studies in Montego Bay and Oyster Bay, Jamaica, from January 1967 to January 1968. The study was in cooperation with the McCullum-Pratt Institute of Johns Hopkins University with funds provided by the Office of Naval Research and the Atomic Energy Commission.

A total of 46 fouling panels was recovered from the two bays. The two sites showed a wide diversity in fouling organisms and in the quantity of biomass as follows:

(1) In Montego Bay, the fouling community was composed almost entirely of algae and a few soft bodied organisms. The biomass remained relatively small.

(2) In Oyster Bay, the growth of hard bodied foulers was rapid, and populations were dense. The biomass rapidly accumulated to a substantial quantity.

A theory is introduced that in certain habitats the seasonal rains may trigger reproduction and settlement in the barnacle, frequently the chief member of the fouling community.

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